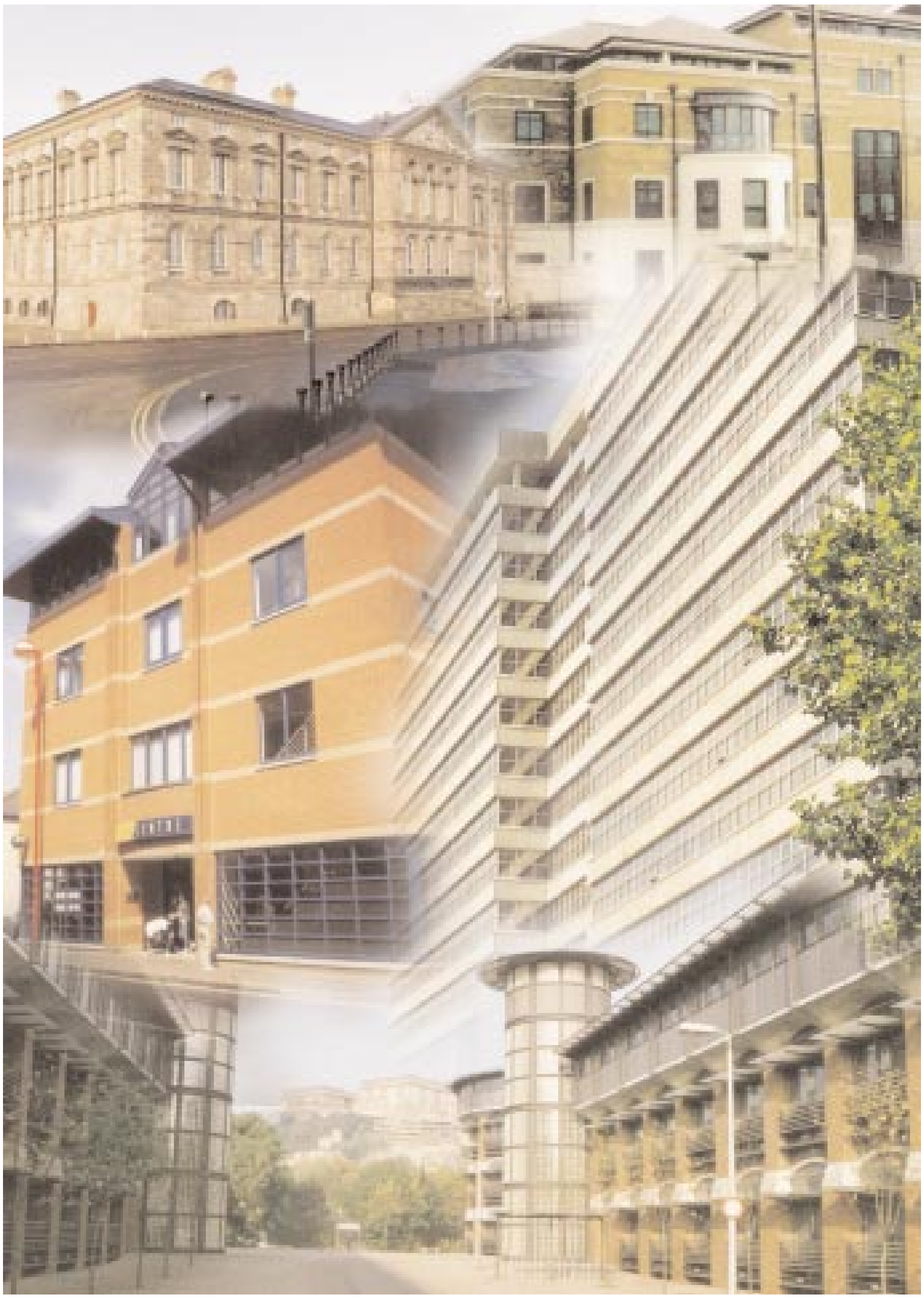
GOOD PRACTICE GUIDE 286

Energy performance in the government's civil estate



- Calculating energy performance and improving energy efficiency
- Comparing energy consumption against benchmarks
- Lowering CO_2 emissions and lessening impact on climate change
- Reducing energy consumption and cost

GOOD PRACTICE GUIDE 286

BEST PRACTICE PROGRAMME
ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

FOREWORD

Man made climate change is one of the biggest problems facing our global community today. Scientists are warning us that the consequences of a gradual shift in the Earth's climatic systems will have a potentially devastating impact upon both society and our own environment. The build up of greenhouse gases, particularly carbon dioxide, is the cause of such effects.

The primary source of greenhouse gas emissions from buildings is due to the energy consumption.

The government is committed to a mix of policies to achieve reductions in greenhouse gases and to meet its climate change targets. Its legally binding target from Kyoto is to reduce emissions of a basket of greenhouse gases to 12.5% below 1990 levels by 2008-2012. It is also working towards its tougher domestic goal of reducing CO_2 emissions by 20% by 2010.

This Guide has been developed to help government departments determine the energy performance of their estate, thereby identifying priority sites in terms of energy use.

The Guide provides a mechanism for ongoing assessment of the civil estate's energy performance when compared against local targets. The Guide also provides advice and guidance on how energy performance improvements may be achieved where considered necessary.

CONTENTS

ACKNOWLEDGEMENTS

This Guide was funded under the Government's Energy Efficiency Best Practice programme.

Acknowledgements are extended to the project steering committee under the Chairmanship of Nick Hayes, Sector Manager at BRECSU.

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Editing and final production of the Guide was undertaken by BRECSU for the Energy Efficiency Best Practice programme.

1 INTRODUCTION

This Guide is designed to help those with responsibility for energy management in office buildings within the government's civil estate. The information in the Guide is intended to assist in the reduction of energy consumption, by helping departmental energy managers set their own energy benchmarks against which the actual energy performance of an office building or site can be compared, and by offering suggestions as to how they can improve energy performance.

Energy managers within the government's civil estate are already required to undertake annual audits of energy consumption. This provides an ideal opportunity for assessing energy efficiency and considering ways to reduce energy consumption and cost. Energy consumption also releases emissions of carbon dioxide (CO_2), a contributor to climate change. Reducing energy consumption is, therefore, important because:

- the government is committed to reducing energy consumption and greenhouse gas emissions as part of the UK Climate Change programme
- energy savings means energy cost reductions
- good energy and environmental management by the government's civil estate sets a good example for the rest of the UK.

THE CIVIL ESTATE

Office buildings in the civil estate range from older refurbished buildings to purpose-built prestige developments. The estate covers a variety of functions, from courts and prisons to specialist laboratory establishments. However, the estate is predominantly office-based, with many of its functions providing services direct to the public, eg Benefits Agency, and Inland Revenue. Overall, the total energy consumption within the civil estate for 1997/98 was over 4 billion kWh.

There are a number of ways of reducing energy consumption in office buildings, often at little or no cost. For example, switching off lights when not required costs nothing other than the need to be vigilant, yet can save 70% of lighting energy costs. Similarly, lowering heating levels by 1ºC can reduce heating energy costs by 10%.

BENCHMARKS

Historically, government departments have assessed their energy performance on a year-on-year basis. Energy benchmarks improve energy management by providing representative values for various types of offices against which a building's actual performance can be compared. Comparison on a regular basis can indicate trends in energy performance. Comparison of a particular building's energy performance against a benchmark for that office building type can also indicate whether there is likely to be scope for improvement. Other advantages of using benchmarks include being able to establish whether a building's poor performance is due to excessive use of fossil fuels or electricity.

Benchmarks are expressed as energy use per square metre of floor area, and are sometimes known as energy usage indicators (EUI) or performance indicators (PI).

The energy use in an office depends on the type and size of the building. For example, a large, fully air-conditioned, prestigious headquarters office is likely to consume more energy per square metre than a small local office. For this reason, office buildings are split into four generic office types. The office types used in this Guide are the same as those published in Energy Consumption Guide (ECON) 19 'Energy use in offices'[1] (see sections 3 and 4).

The benchmarks presented in this Guide are most appropriate for buildings with floor areas of 1000 m^2 or more, although they can be used for smaller sites. They allow for actual hours of use including regular overtime and weekend work, and the wastage and inefficiencies that inevitably occur to some degree, in even the best-managed environments.

It should be remembered that benchmarks are intended to give a guide to performance only, as it is not an exact process.

ABOUT THIS GUIDE

This Guide is intended to assist in the reduction of energy consumption by providing:

- advice on energy and environmental management, including roles and responsibilities (pages 6 and 7)
- energy benchmarks for various types of office building (page 8)
- guidance on comparing performance of the civil estate, plus an example calculation (pages 9 to 15)
- advice and guidance on data collection and performance assessment (pages 16 to 18)
- typical saving opportunities (inserts in pocket of back cover).

The inserts describing typical saving opportunities are designed to be copied and passed to individuals with responsibility for specific areas of a building or site. A checklist is included showing typical energy-saving opportunities, and appendices address the issues of degree days and benchmarks for buildings other than offices.

2 ENERGY AND ENVIRONMENTAL MANAGEMENT

The processes outlined in this section are equally applicable to energy and environmental management, although this Guide concentrates on energy management.

THE KEY COMPONENTS

The three most important components of successful energy and environmental management are management, technology and people.

- ***Management.*** The management of energy incorporates many different organisational issues (see Good Practice Guide (GPG) 167 'Organisational aspects of energy management: a self-assessment manual for managers'[2]). Energy must be managed as well as any other budget of a similar magnitude. Energy costs are not fixed but are controllable and should be managed accordingly. This includes the management of contractors.
- ***Technology.*** Wherever possible, the best possible technologies should be utilised to ensure efficient energy use with minimal environmental impact.
- ***People.*** The most cost-effective energy management is obtained often as a result of good management of occupants. Highly aware and motivated occupants will lead to the lowest energy costs.

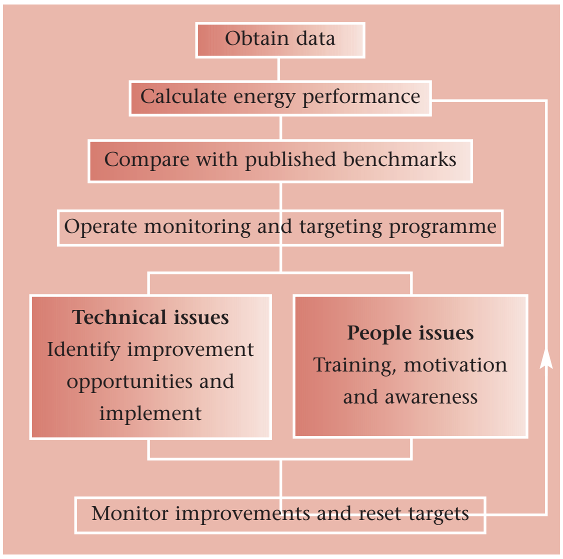


Figure 1 An integrated approach to energy and environmental management

Figure 1 illustrates an integrated approach to energy and environmental management, that encompasses technical and people issues, which are key to the success of the approach. Because the technical and people issues have such a fundamental impact on the overall approach, they are covered in this section, ahead of the guidance on using benchmarks and comparing energy performance.

ROLES AND RESPONSIBILITIES

The responsibility for managing energy within a building or group of buildings must be clearly understood by everyone concerned.

It is necessary to understand fully the relationships between the departmental energy manager (DEM), local accommodation manager (LAM) or officer, maintenance contractors (internal or external), and occupants. For example, if an accommodation officer is unclear as to his/her particular responsibilities, it is quite likely that the maintenance/facilities management contractor will be similarly unclear, the result being little or no proactive energy management.

Poor maintenance is a major cause of energy waste within a building and it is necessary for the accommodation manager to be aware of this. Careful monitoring and targeting (M&T) and checking of heating performance (see section 5 and insert 2) can give good indication of the effectiveness of the contractor's performance. It is important that the maintenance contractor is fully aware of his responsibilities and duties and that these are covered by a contract agreement.

Therefore it is recommended that:

- an 'energy focal point' is established for each building
- any existing contractual arrangements are clearly understood by all parties
- any existing structure is clearly understood or, if necessary, a new formal structure is adopted that clearly identifies the energy focal point, and everyone's roles and responsibilities.

Depending on the size and nature of a building, or group of buildings, the energy focal point could be the LAM, maintenance contractor, works services manager, etc.

ENERGY AND ENVIRONMENTAL MANAGEMENT

Also, it is important to understand and clearly define the energy management roles and responsibilities when considering refurbishment works and new-build contracts. This is an ideal time for incorporating energy management techniques and investing in energy efficiency. If any improvements can be undertaken as part of such work, the payback period will be considerably less than if the same improvements were made retrospectively.

Once everyone's roles and responsibilities are understood, a clear energy management strategy is needed. For more details refer to GPG 200 'A strategic approach to energy and environmental management'[3].

SAVING OPPORTUNITIES

The potential saving opportunities fall into two separate categories:

- those made through applying 'technical fix' solutions
- those made through better management.

These categories are equally important, so it is necessary to prioritise opportunities on an individual basis.

Technical measures

Undertaking an energy survey of a site or building will identify all the economically viable technical improvements that can be made to reduce energy consumption.

The most common technical fix opportunities are covered in detail on the inserts at the back of this Guide. However, it is worth comparing the annual energy consumption against the performance benchmarks (see section 3) before and after implementing energy efficiency measures. This will provide an assessment of the actual effectiveness of those measures.

For further information see GPG 117 'Energy efficiency in the government estate – for accommodation managers'[4].

People aspects

To obtain a good, sustained level of energy management, technical measures can only provide part of the solution. Once all the economically viable technical measures have been undertaken the only scope for further improvement is through better manual control of energy usage. People aspects include raising awareness and improving staff motivation. Good energy housekeeping can save 20% of energy consumption, so it is clearly worth encouraging staff to co-operate by switching off appliances, equipment and lights when not required.

It is essential that everybody in an organisation is aware of the contribution they can make and that they are motivated to ensure savings are sustained. For further information refer to GPG 84 'Managing and motivating staff to save energy'[5].

CARBON DIOXIDE EMISSIONS

The environmental consequences of energy consumption are likely to impact on national policies concerning emissions of CO_2 and other greenhouse gases. Therefore, it is important to highlight the relationship between energy consumption and CO_2 emissions.

Each kWh of energy delivered to a building incurs atmospheric emissions of the major greenhouse gas CO_2, the principal contributor to global warming. For comparative purposes with other statistics, CO_2 emissions in this Guide are quoted as kg of carbon per kWh of fuel delivered (kgC/kWh).

Table 1 shows that gas contributes lower CO_2 emissions than electricity (gas also costs less than electricity). Therefore, it makes good economic and environmental sense to use gas rather than electricity, although this is not always feasible.

Fuel	kgC/kWh	kgCO_2/kWh
Gas	0.052	0.19
Oil	0.069	0.25
Coal	0.081	0.30
Electricity	0.127	0.46

Table 1 Conversions factors for various energy sources

Note: The conversion factor for electricity varies with the primary fuel mix used to generate it. In the UK, it is currently falling and projections suggest that it will reach 0.11 kgC/kWh or lower by the year 2000.

3 THE BENCHMARKS

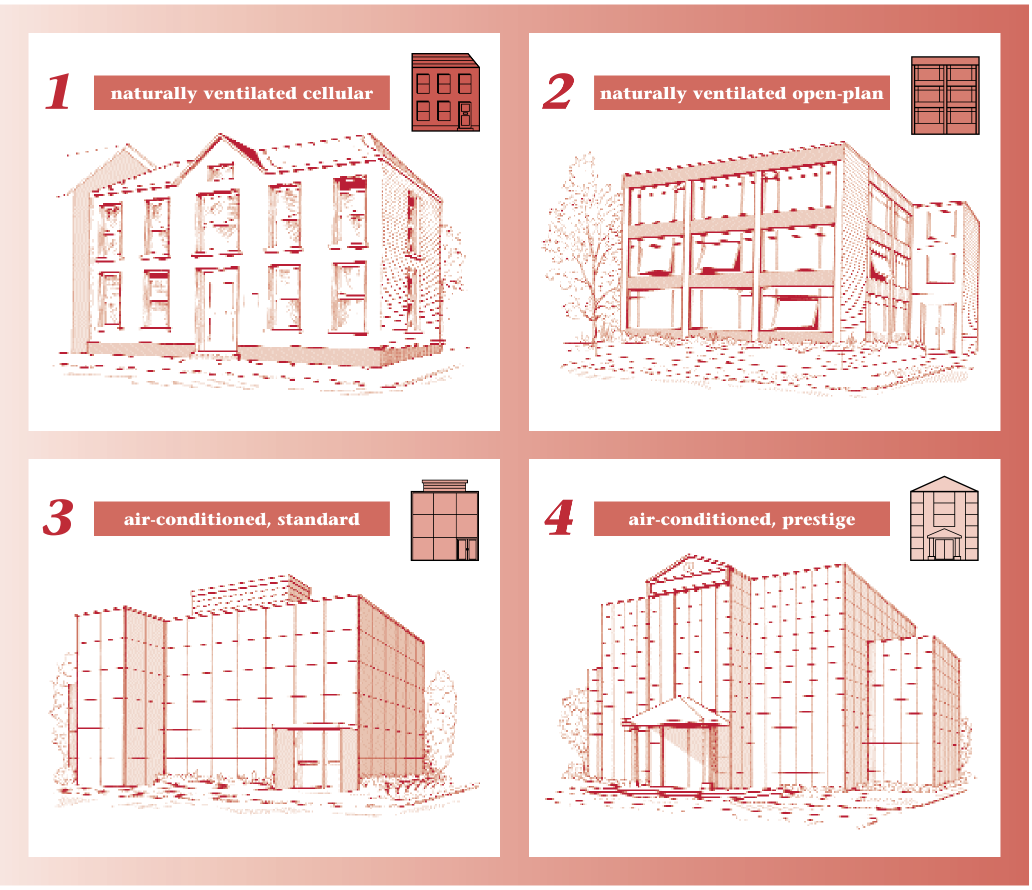
TYPES OF OFFICES

ECON 19[1] defines four office types, and these are used as the basis for comparison with office buildings of the civil estate. How the comparison is made is explained in section 4 together with an example calculation. At this stage it is useful to be aware of the four categories in order to consider the buildings for which you have responsibility and how they may compare with the four types.

The four generic office types are shown below.

ECON 19 BENCHMARKS

The energy consumption benchmarks against which the energy performance of the civil estate should be compared are shown in table 2 (the assumptions are shown in section 4). Initially, all office buildings should strive to do better than the 'typical' benchmarks. The 'good practice' values show what can be achieved, particularly within new office buildings.



	1		2		3		4	
	Typical	*Good practice*	*Typical*	*Good practice*	*Typical*	*Good practice*	*Typical*	*Good practice*
Total gas or oil	151	79	151	79	178	97	210	114
Total electricity	54	33	85	54	226	128	358	234
Total kWh/m^2 per year	205	112	236	133	404	225	568	348

Table 2 Energy consumption benchmarks for the four types of office building

4 COMPARING PERFORMANCE AGAINST THE BENCHMARKS

CALCULATING ENERGY PERFORMANCE

Comparing a building's actual annual energy consumption with the appropriate benchmark can enable the standard of energy efficiency of that building to be assessed, and indicate whether there is likely to be scope for improvement.

To assist energy managers in making an accurate calculation of energy performance, this Guide includes a blank form for photocopying and issuing to those responsible for individual buildings and sites (see appendix 1). Figure 2 shows an example of a completed form. Five separate inputs are required to complete the form, and these are described in this section, together with guidance on how to compare the performance value with the site or building typical benchmark.

The five inputs are:

- **Input 1** the office 'type'
- **Input 2** the treated floor area
- **Input 3** the annual energy consumption
- **Input 4** the local degree days
- **Input 5** the weekly hours of occupancy.

The guidance below will help you complete the form.

Input 1 IDENTIFY THE OFFICE TYPE

From the descriptions below it may be possible to match some office buildings to just one of the four types. However, many office buildings are made up of a combination of the four types. The most common 'mix' is between types 2 and 3, where a building is largely naturally ventilated, open-plan, ie a type 2, but also contains a proportion of air-conditioned space usually for computer, communication, reprographic equipment, etc, ie a type 3 space. If this is the case, it is necessary to roughly assess the relative proportions by floor area of each type, eg 80% type 2 and 20% type 3.

If you are unsure what type(s) your building is ask your local, regional or national energy focal point (see the back cover).

Type 1 Naturally ventilated – mostly cellular

- A simple building, often (but not always) relatively small and sometimes in converted residential accommodation.
- Typical core occupancy is for 48 hours per week (including flexi hours, regular overtime, weekend work, etc).

These offices have often been converted from houses, shops, etc, with individual opening windows, low illuminance levels, local light switches and heating controls. This helps to match the operation of lighting and heating to the needs of occupants and, in particular, tends to reduce electricity consumption. There also tend to be few common facilities. Catering often consists of the 'odd' sink, refrigerator and kettle.

Type 2 Naturally ventilated – mostly open-plan

- Largely open-plan but with some cellular offices and special areas.
- Typical core occupancy is for 58 hours per week (including flexi hours, regular overtime, weekend work, etc).

This type is usually purpose built. Illuminance levels, lighting-power densities and hours of use are usually higher than in type 1 offices. There is more office equipment and vending machines, etc, and more regular use of this equipment. Lights and shared equipment tend to be switched in larger groups, and stay on for longer because it is more difficult to match supply to demand.

Type 3 Air-conditioned – standard, mostly open-plan

- Largely purpose-built and often speculatively developed.
- Typical core occupancy is for 62 hours per week (including flexi hours, regular overtime, weekend work, etc).

This type is similar in occupancy and planning to office type 2, but usually with a deeper floor plan, and sometimes tinted or shaded windows which reduce daylight still further. These buildings can often be more intensively used. The benchmarks are based on variable air volume (VAV) air-conditioning with air-cooled water chillers; other systems often have similar overall consumptions but a different composition of end use. (See GPG 71 'Selecting air conditioning systems. A guide for building clients and their advisers'[6].)

COMPARING PERFORMANCE AGAINST THE BENCHMARKS

Site name: *A Government Office*

Site address: *10 High Street*
Any Town

Site Ref. (if any) *1234*

Input 1

'Type(s)' of office space

	1	2	3	4
Approximate % by floor area	*0%*	*85%*	*15%*	*0%*

Input 2

Treated floor area (TFA): *3,500* m^2

Input 3

Annual energy consumptions:

		Are these consumptions based on estimates? Yes	No
Electricity (kWh)	*745,150*		✓
Gas/oil/coal (kWh)	*515,255*		✓
Total annual consumption	***1,260,405*** **kWh**		

If gas/oil/coal consumption is zero:

	Yes	No
Is building heated electrically?		
Is heating paid for by landlord?		

This consumption covers the 12 months: *April '98* to *Mar '99*

Input 4

The local degree days for this period were: *2,253*

Input 5

Normal weekly occupancy hours *64* Hours

	Yes	No
Is any part of the building occupied 24 hours?	✓	

If yes, what % of the building is this? *1* %

	Yes	No
Is this area heated separately?	✓	

Completed by: *Mr Smith* Date: *21/4/99*

Contact telephone number: *01234 123456*

Any other comments:
The Inland Revenue occupies approx. 15% of our building. They pay for their electricity but we pay for their heat.

Figure 2 Completed 'example' energy consumption performance form

COMPARING PERFORMANCE AGAINST THE BENCHMARKS

Type 4 Air-conditioned – prestige, cellular and open-plan

- A national or regional head office or technical/administrative centre.
- Typical core occupancy is for 67 hours per week (including flexi hours, regular overtime, weekend work, etc).

This type is purpose-built or refurbished to high standards. Plant operating hours are often longer to suit the diverse occupancy. These buildings generally include catering kitchens (serving hot lunches for about half the staff); areas for mainframe computers and communications equipment; and sometimes extensive storage, parking and leisure facilities. (These facilities may be found in offices of other types and if so, should be allowed for.)

Input 2 DETERMINE THE TREATED FLOOR AREA IN m^2

The floor area needed is the treated floor area (TFA), ie the area that is heated. Quite often, however, the only area that is known is the agent's lettable area (ALA). If this is the case, the TFA can be approximated for all office types as:

TFA = ALA × 1.25

Sometimes, for newer buildings, only the gross internal area (GIA) may be known, ie the total building area measured inside external walls.
If this is the case, the TFA can be approximated as:

- for types 1 and 2: TFA = GIA × 0.95
- for type 3: TFA = GIA × 0.90
- for type 4: TFA = GIA × 0.85

Areas are often quoted in square feet, where
10.76 ft^2 = 1 m^2

Input 3 ESTABLISH THE TOTAL ANNUAL DELIVERED ENERGY CONSUMPTION

Adding together the electrical and fossil-fuel energy streams, establish the total annual delivered energy consumption:

- electricity ....kWh
- fossil fuel (ie gas + oil + coal) ....kWh

Wherever possible, actual consumptions should be used rather than estimates. For more information see 'data collection' in section 5 and table 3 for conversion factors.

Some useful conversion factors

- 3.6 MJ = 1 kWh
- 3.6 GJ = 1000 kWh
- 100 000 Btu = 1 therm = 29.31 kWh
- 100 ft^3 = 28.3 m^3

Input 4 ESTABLISH THE DEGREE DAYS

Degree days are a measure of the variation of outside temperature that enables the energy consumption of a building to be related to the weather. A more detailed explanation of degree days is contained in appendix 4 of this Guide.

Across the country, the local weather conditions can vary significantly. To allow for this, degree days are published for 18 different locations across the UK, that are broadly representative of the local area. Table 4 (overleaf) lists the regional breakdown.

Fuel type	Typical gross calorific value	Unit of supply		
Electricity	1 kWh/unit	1 kWh	=	1 kWh
Natural gas	38.2 MJ/m^3	1 m^3	=	10.6 kWh
Gas oil/35 sec oil (class D)	38 MJ/litre	1 litre	=	10.6 kWh
Heavy fuel oil (class G)	42 MJ/litre	1 litre	=	11.7 kWh
Coal	28.6 GJ/tonne	1 kg	=	7.9 kWh
Propane	50.0 GJ/tonne	1 kg	=	13.9 kWh
Butane	49.3 GJ/tonne	1 kg	=	13.7 kWh

Table 3 Conversion factors for various fuels

COMPARING PERFORMANCE AGAINST THE BENCHMARKS

Region number	Region
1	Thames Valley
2	South Eastern
3	Southern
4	South Western
5	Severn Valley
6	Midland
7	West Pennines
8	North Western
9	Borders
10	North Eastern
11	East Pennines
12	East Anglia
13	West Scotland
14	East Scotland
15	NE Scotland
16	Wales
17	Northern Ireland
18	NW Scotland

Table 4 Showing the UK's regional breakdown for degree day data

Degree-day correction is applied to the fuel used for space-heating (usually fossil fuel) together with any other use for that fuel, eg hot water production.

The energy consumption data obtained for Input 3 will have occurred over a certain 12-month period. If this were a particularly cold period the energy consumption would be higher than if it were a mild period. It is necessary therefore to establish the total local degree days to the same 12-month period as the energy data.

Regional annual degree day figures for the current year can be obtained from your departmental energy manager or the Energy Efficiency Best Practice programme website: www.energy-efficiency.gov.uk

For further information on degree days call your local regional environmental and energy management contact (see the back cover for details).

Input 5 HOURS OF USE

For each of the four office types, the weekly hours of occupation are different. The assumed occupation hours, including flexi hours, regular overtime, weekend working, but excluding occupancy by cleaners, maintenance staff, etc, are given in table 5.

Where the hours of use for a particular building are different from those used in the benchmarks then occupancy correction is required (as illustrated by example 1 in appendix 2). This adjustment is only valid in predominantly five-day week occupied buildings.

However, where a building has extended hours of occupancy, including weekend and 24-hour working, a separate adjustment for electricity and fossil-fuel consumption is necessary. For electrical energy performance the adjustment should be made on a pro rata basis for the hours occupied. For fossil fuels, the correction factor is very much dependent on the structure of the building. For the purpose of this Guide the correction factors shown in table 6 should be used, and are illustrated by example 2 in appendix 2.

	Assumed hours of occupation per week
Type 1	48
Type 2	58
Type 3	62
Type 4	67

Table 5 Occupation by office type

Occupancy period	Correction factor
Additional 15 hours per week, eg weekend working	0.95
Continuous working (seven-day week)	0.8

Table 6 Occupancy correction factors for fossil-fuel consumption

COMPARING PERFORMANCE AGAINST THE BENCHMARKS

CALCULATING THE ADJUSTED ENERGY CONSUMPTION

Calculating the adjusted energy performance for a building and its corresponding benchmark is fairly complicated. This calculation should either be done by your national or regional energy focal point or by using the benchmarking tool available from the Energy Efficiency Best Practice programme website (www.energy-efficiency.gov.uk). Appendix 2 contains examples showing the calculations using the benchmarking tool.

A typical output from the calculation is shown in figure 3.

MAKE THE COMPARISON

The output from the benchmark calculation gives the percentage improvement needed to reach 'typical'. Clearly a negative value (eg -12.5%) indicates that the building is already better than typical.
Buildings with adjusted consumption that need improvements of greater than 50% to reach typical warrant immediate further investigation. In these situations there are likely to be considerable energy-saving opportunities, often for little or no capital cost. In buildings requiring improvements of up to 50%, savings are usually possible but greater levels of investment may be needed, and payback periods will generally be longer. Even in buildings with adjusted consumption better than typical (ie negative percentages), cost-effective savings can nearly always be found.

SUBSEQUENT YEARS

In subsequent years, in order to calculate the adjusted consumption only a relatively small amount of information will be needed, as most of the other factors such as address, type, occupancy, etc, will not change. As such, only Input 3 and Input 4 are required.

Figure 3 Showing the output of a typical calculation

COMPARING PERFORMANCE AGAINST THE BENCHMARKS

Clearly, however, if any significant changes on site have been made, ie a new extension, revised occupancy patterns, installation of air-conditioning plant, etc, then the energy-performance data form shown in appendix 1 should be used again.

FURTHER ANALYSIS

The energy performance of every significant building within the civil estate is required to be calculated at the end of each financial year.

Calculating performance more frequently, ie six monthly, quarterly or even on a monthly basis, for each utility can, however, be an extremely useful and worthwhile exercise. This enables month-by-month trends in consumption efficiency to be established. Also, the benefits resulting from implementing a particular initiative or group of measures on a site can be measured.

It is also possible to use benchmarks to help with the initial 'detective work' when analysing the energy performance of a building. This is a particularly useful technique that can help to establish priorities or identify areas for further investigation.

Usually, it is worthwhile examining not just the benchmark for the whole building but the separate benchmarks for the fossil fuel and electricity, and their components. Additionally, if areas of the building are sub-metered, calculating the energy performance for these areas can also be helpful.

Table 7 presents the expected breakdown of energy usage (kWh/m^2) within each office type (for further detail, please refer to ECON 19[1]).

Further analysis of a building's half-hourly electrical demand profiles (typically available for sites with a maximum demand greater than 100 kW, and sometimes for smaller sites), or night-time electricity demand compared with the daytime usage, etc, can help to maximise the benefits from site investigation. This type of analysis can indicate areas of wastage, or even the specific time of day that requires further investigation.

It is also sometimes worthwhile installing temporary monitoring equipment on main electrical loads, eg computer suites, refrigeration plant, etc, to help to understand their power requirements.

	1		2		3		4	
	Typical	*Good practice*	*Typical*	*Good practice*	*Typical*	*Good practice*	*Typical*	*Good practice*
Heating and hot water – gas or oil	151	79	151	79	178	97	201	107
Cooling	0	0	2	1	31	14	41	21
Fans, pumps, controls	6	2	8	4	60	30	67	36
Humidification (where fitted)	0	0	0	0	18	8	23	12
Lighting	23	14	38	22	54	27	60	29
Office equipment	18	12	27	20	31	23	32	23
Catering, gas	0	0	0	0	0	0	9	7
Catering, electricity	3	2	5	3	6	5	15	13
Other electricity	4	3	5	4	8	7	15	13
Computer room (where appropriate)	0	0	0	0	18	14	105	87
Total gas or oil	**151**	**79**	**151**	**79**	**178**	**97**	**210**	**114**
Total electricity	**54**	**33**	**85**	**54**	**226**	**128**	**358**	**234**
Total kWh/m^2 per year	**205**	**112**	**236**	**133**	**404**	**225**	**568**	**348**

Table 7 Breakdown of energy use within each office type (kWh/m^2)

COMPARING PERFORMANCE AGAINST THE BENCHMARKS

CASE STUDY 1

An almost new, well-insulated, air-conditioned government office building (ie a type 3 building) had an energy performance of 311 kWh/m^2. Referring to table 2, for a type 3 building, this is approximately mid-way between the good practice and typical figures. As the building was almost new, it was expected to be nearer good practice. Some investigation on site was required as it was unclear as to where the energy wastage was occurring.

A further analysis of the performance indicated that the fossil-fuel (gas) performance was 101 kWh/m^2 and the electricity performance was 210 kWh/m^2. This further analysis (using table 7) clearly showed that the building's gas-related energy consumption services (ie heating and hot water) were running efficiently, with the performance being only slightly higher than the good practice benchmark of 97 kWh/m^2. However, the electrical performance of 210 kWh/m^2 was well in excess of the good practice benchmark of 128 kWh/m^2.

As a result of this further analysis, the site investigation work was targeted at electrical services and in particular the cooling, fans, pumps, controls and lighting (ie the greatest components of electrical consumption, suggested by table 7). This identified that the air-handling controls were set incorrectly and a zero-cost adjustment of the controls reduced the site's electrical consumption by over 30%.

If the further analysis of the benchmark figures had not been undertaken, several hours of wasted site work investigating the operation of the boiler plant and hot water services may have been undertaken.

5 MONITORING AND TARGETING

The use of management techniques to control energy consumption and costs is known as energy monitoring and targeting (M&T). In most organisations, the consumption of resources, whether manpower or materials, is managed in a disciplined manner. Energy usage, however, is often not managed strictly and is treated as just another overhead. This can be corrected by the use of M&T.

This part of the Guide deals specifically with the problems associated with collecting utility consumption data. In order to run an effective M&T system the following additional items of data may also need collecting/checking:

- degree days
- site details, including floor areas, etc
- building occupancy patterns, etc.

DATA COLLECTION

The utilities that need to be monitored are:

- electricity
- fossil fuels, ie gas, fuel oils, coal
- water.

Collection of metered consumption data should not only be seen as a means towards effective M&T, as often the most important reason for data collection is to validate utility invoices and accounts. Where actual meter readings are collected, these can be used to correct consumptions estimated by the utility supplier. Providing this information to whoever passes the invoices for payment can often produce immediate savings that can then be used to fund energy management initiatives. Furthermore, validation of other accounts must be taking place within the organisation so, by incorporating M&T into this function, cost savings can be made.

Data collection procedures

Two issues are important when considering data collection procedures:

- the frequency and timing of data collection
- the mechanism used to collect data.

Data collection frequency

The selection of the correct data collection frequency is crucial to the success of M&T. If too much data is collected, then the data-processing effort could start to cost more than the potential savings. On the other hand, if data is not collected with sufficient frequency, the reasons for any consumption, and hence cost increases, may not be remembered. Even if they are known, the increase will continue for longer before being addressed.

For most government buildings, monthly preparation of M&T data will usually provide the best balance between excessive processing effort and excessive data coarseness. This reporting frequency is also convenient, as it enables monthly M&T reports to be integrated with other month-end reports.

However, there may be some buildings or sites that, due to their high consumptions, warrant a weekly collection frequency.

The timing of meter readings is also important. Ideally, each meter should be read at the same time, on the same day every week or month. For monthly readings, a difference of about 4% can result for each day that the reading is taken before or after the usual day.

A Wednesday is often a good day for meter readings as, generally, it does not clash with a bank holiday.

CASE STUDY 2

At one government site, all main utility meters and sub-meters were religiously read on a weekly basis. However, on further investigation, not all the units of consumption were correct and staff did not know what some of the sub-meters were supplying.

It is, therefore, important to establish the units that the meters are recording, eg kWh, 100's cubic feet, litres, m^3, etc, and also any correction or multiplying factors that need to be applied to the readings. Additionally, it is important to fully understand what each meter and sub-meter is supplying.

MONITORING AND TARGETING

Data collection mechanisms

There are four methods of collecting metering data:

- monthly utility invoices
- manual data collection (ie meter reading)
- semi-automatic data collection using a portable data logger/hand-held computer
- fully automatic data acquisition, eg via a building management system (BMS).

This Guide deals with manual collection, as it is often the simplest and cheapest method of data collection and is, therefore, the most widely used. It has the added advantage of ensuring that the meter readings are taken and used locally, which is the most effective way of monitoring energy.

Manual collection should always be used for a pilot scheme, even if more sophisticated collection methods are planned, since it provides a means of learning for the user. The usual procedure is to use an M&T package to generate a meter-reading form that lists the meters in the order they are read on site, and that shows the previous reading, for reference. This form is sent to the person responsible for reading the meters. After completion, it is returned to the M&T operator (ideally the energy focal point). It is often useful to customise the form for different meters/utilities to assist the meter reader. Although the printout of the previous meter reading should help to reduce errors, they still occur for a number of reasons:

- incorrect reading of the meter
- meter readings are sometimes noted on scraps of paper before the form is completed neatly and sent to the M&T operator
- difficulty in reading handwritten figures
- inaccurate typing during data entry.

The most effective way of minimising these errors is to provide guidance and training for the meter readers. This can stress the importance of providing accurate and reliable data as well as providing specific training in how to read different types of meter.

Whenever data is collected manually, either with or without a logger, there are a number of key points that should be noted.

- At least two people should know the location of all meters. Arrangements should be made to ensure that meters are read at the appropriate time in the event of sickness or holiday.
- Meter readings should be taken at such a time that metered consumptions correspond with normal reporting periods, eg month end.
- Meters should be read at the same time each week/month. This minimises the need for interpolation between meter-reading dates.
- Appropriate resources have to be allotted to meter reading, particularly for large sites, or those with large numbers of meters.
- Manual data collection means that the whole site is walked regularly. This provides an opportunity to observe and report faults that might otherwise remain undetected.

For further information on the operation of M&T systems refer to GPG 31 'Computer aided M&T for industry'[7].

DATA ANALYSIS

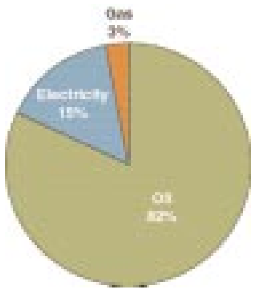
Analysis of information from meter readings or invoices assists in the selection of priorities. Data from individual sites should be reviewed as follows.

- Identify each individual energy/utility type to be analysed.
- Make special note of any estimated readings. Estimates are usually based on the consumption for the corresponding period in the previous 12 months and although they may be fairly accurate, should be used with caution.
- Convert the consumption of each energy stream to a common unit using standard conversion factors (see table 3).
- Calculate the percentage breakdown of total energy consumption and cost by energy type and determine the average overall cost per kWh to indicate its relative significance.

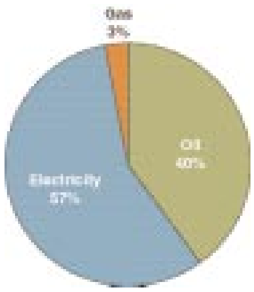
PRESENTATION OF DATA

A summary table should be prepared for each building or cost centre showing consumption and cost. It is also useful to include the relative proportions of total cost and energy consumed

MONITORING AND TARGETING



Energy consumption



Energy cost

Figure 4 Showing how pie charts can illustrate energy consumption and cost

by each fuel type and to note the overall unit cost of each fuel. An example is shown in table 8. Pie charts can also be used to illustrate the relative proportions of consumption and cost attributable to each fuel, as shown in figure 4.

PERFORMANCE ASSESSMENTS

A preliminary assessment is a comparison of performance with typical consumption levels that should help you to:

- obtain an indication of the scope for potential improvement
- identify which utility should have priority
- compare buildings with typical and good practice
- measure progress over time.

In its simplest form, an assessment will entail establishing a league table of buildings or sub-metered areas, identifying energy consumption and cost and, where the previous year's data is available, a comparison with the most recent year.

Energy type	Purchased units	Consumption		Cost		Energy unit cost
		kWh	%	£	%	p/kWh
Electricity	902 500 kWh	902 500	15	37 400	57	4.14
Gas	15 183 m^3	161 121	3	1 880	3	1.17
Oil (Class G)	440 000 litres	5 133 744	82	26 200	40	0.51
Total	–	6 197 365	100	65 480	100	–

Table 8 An example summary table showing consumption and cost

CASE STUDY 3

A simple assessment of the annual energy data from three similar government office buildings is shown in the table below.
Building A has shown a 10% increase in energy consumption over the previous year, and so may be assumed to be the worst performer.

	Energy consumption (kWh)		
	Previous year	Most recent year	% change
Building A	1 400 000	1 540 000	+10.0
Building B	1 700 000	1 643 900	–3.3
Building C	275 000	275 000	0

However, at this stage no correction has been made for other factors that might affect the comparison. For example, the data could be modified to take into account the individual building floor areas or volumes, as shown below.

Most recent year	Consumption (kWh)	Floor area (m^2)	Consumption/m^2 (kWh/m^2)	Year on year % change in consumption
Building A	1 540 000	6700	230	+10.0
Building B	1 643 900	6500	253	–3.3
Building C	275 000	1100	250	0

This further assessment indicates that while Building A has shown a 10% increase in energy consumption over the previous year, this may be as a result of poor housekeeping or incorrectly set controls. However, its overall efficiency is considerably better than Buildings B or C, both of which may yield greater no-cost or low-cost savings.

APPENDIX 1 ENERGY PERFORMANCE DATA FORM

Site name: ____________________

Site address: ____________________

Site Ref. (if any) ____________

Input 1

'Type(s)' of office space

	1	2	3	4
Approximate % by floor area				

Input 2

Treated floor area (TFA): ____________ m^2

Input 3

Annual energy consumptions:

		Are these consumptions based on estimates? Yes	No
Electricity (kWh)	____________		
Gas/oil/coal (kWh)	____________		
Total annual consumption	____________ **kWh**		

If gas/oil/coal consumption is zero:

	Yes	No
Is building heated electrically?		
Is heating paid for by landlord?		

This consumption covers the 12 months: ____________ to ____________

Input 4

The local degree days for this period were: ____________

Input 5

Normal weekly occupancy hours ____________ hours

	Yes	No
Is any part of the building occupied 24 hours?		

If yes, what % of the building is this? ____________ %

	Yes	No
Is this area heated separately?		

Completed by: ____________ Date: ____________

Contact telephone number: ____________

Any other comments:

APPENDIX 2 CALCULATING THE ADJUSTED PERFORMANCE AND TARGET BENCHMARK

EXAMPLE 1

This example is for a site with a TFA of 3500 m^2, comprising type 2 (85% of floor area) and type 3 (15% of floor area) offices. The building is occupied for 64 hours (single-shift five-day working week). The overall annual electrical consumption is 745 150 kWh and the annual fossil-fuel consumption is 515 255 kWh.

INPUT DATA

Input 1

% floor area type 1 = nil	**A**
% floor area type 2 = 85	**B**
% floor area type 3 = 15	**C**
% floor area type 4 = nil	**D**

Input 2

Floor area (TFA) (m^2) = 3500	**E**

Input 3

Annual electrical consumption (kWh) = 745 150	**F**
Annual gas/oil/coal consumption (kWh) = 515 255	**G**

Input 4

Local degree days = 2253	**H**

Input 5

Weekly occupancy hours = 64	**I**

Calculation

Degree day correction to heating (normally fossil fuel). The calculation for fossil fuel is shown as follows. If you have electric heating, discuss with your DEM.

$$\left(\mathbf{G}\ 515\ 255 \times \frac{2462}{\mathbf{H}\ 2253}\right) = \mathbf{K}_{\text{FOSSIL}}\ 563\ 053\ \text{kWh}$$

Hours correction factor (to be applied to all fuels) – see page 12 (Input 5 and table 5)

Because most office buildings comprise a combination of types, the hours correction factor (Z) reflects the percentage of each building type:

$$\left(\left(\frac{\mathbf{A}}{100} \times \frac{48}{\mathbf{I}}\right) + \left(\frac{\mathbf{B}}{100} \times \frac{58}{\mathbf{I}}\right) + \left(\frac{\mathbf{C}}{100} \times \frac{62}{\mathbf{I}}\right) + \left(\frac{\mathbf{D}}{100} \times \frac{67}{\mathbf{I}}\right)\right) = \mathbf{Z}$$

However, because the site does not include type 1 or type 4 office space, the actual calculation is:

$$\left(\left(\frac{\mathbf{B}\ 85}{100} \times \frac{58}{\mathbf{I}\ 64}\right) + \left(\frac{\mathbf{C}\ 15}{100} \times \frac{62}{\mathbf{I}\ 64}\right)\right) = \mathbf{Z}\ 0.92$$

Site energy performance (fossil fuels)

$$\mathbf{Z}\ 0.92 \times \frac{\mathbf{K}_{\text{FOSSIL}}\ 563\ 053}{\mathbf{E}\ 3500} = \mathbf{L}_{\text{FOSSIL}}\ 148\ \text{kWh/m}^2$$

APPENDIX 2

Site typical benchmark (fossil fuels)

Because most office buildings comprise a combination of types it is necessary to take this into consideration to arrive at a site typical benchmark, as shown below.

The calculation for site typical benchmark is:

$$\frac{(\mathbf{A} \times 151)}{100} + \frac{(\mathbf{B} \times 151)}{100} + \frac{(\mathbf{C} \times 178)}{100} + \frac{(\mathbf{D} \times 210)}{100} = \mathbf{N}_{\mathrm{FOSSIL}}$$

However, because the site comprises only type 2 and 3 offices, the actual calculation is:

$$\frac{(\mathbf{B}\ 85 \times 151)}{100} + \frac{(\mathbf{C}\ 15 \times 178)}{100} = \mathbf{N}\ 155\ \mathrm{kWh/m^2}$$

Percentage improvement needed

$$\frac{(\mathbf{L}\ 148 - \mathbf{N}\ 155)}{148} \times 100 = \mathbf{P}\ -4.7\%\ \text{(4.7\% better than typical)}$$

Site energy performance (electrical)

$$= \frac{\mathbf{Z}\ 0.92 \times \mathbf{F}\ 745\ 150}{\mathbf{E}\ 3500} = \mathbf{L}_{\mathrm{ELECTRICAL}}\ 196\ \mathrm{kWh/m^2}$$

Site typical benchmark (electrical)

$$= \frac{\mathbf{A} \times 54}{100} + \frac{\mathbf{B} \times 85}{100} + \frac{\mathbf{C} \times 226}{100} + \frac{\mathbf{D} \times 358}{100} = \mathbf{N}_{\mathrm{ELECTRICAL}}$$

However, because the site comprises only type 2 and 3 offices, the actual calculation is:

$$\frac{(\mathbf{B}\ 85 \times 85)}{100} + \frac{(\mathbf{C}\ 15 \times 226)}{100} = \mathbf{N}\ 106\ \mathrm{kWh/m^2}$$

Percentage improvement needed

$$\frac{(\mathbf{L}\ 196 - \mathbf{N}\ 106)}{196} \times 100 = \mathbf{P}\ 46\%$$

Summary table (please enter results to give overall site performance)

Fuel	Energy performance (kWh/m²)		Site typical (kWh/m²)		Improvement needed
Fossil	$\mathbf{L}_{\mathrm{FOSSIL}}$	148	$\mathbf{N}_{\mathrm{FOSSIL}}$	155	–5%
Electrical	$\mathbf{L}_{\mathrm{ELECTRICAL}}$	196	$\mathbf{N}_{\mathrm{ELECTRICAL}}$	106	46%
Overall	$\mathbf{L}_{\mathrm{OVERALL}}$	344	$\mathbf{N}_{\mathrm{OVERALL}}$	261	24%

In this example, electrical energy usage clearly needs to be investigated. Please refer to 'further analysis' on page 14 of this Guide for a breakdown on electrical energy end use.

APPENDIX 2

EXAMPLE 2

This example is for the same site as shown in example 1, except that the site now operates continually, 24 hours per day over a seven-day week. The only difference in the procedure is the calculation of degree day correction and the calculation for occupancy correction. However, data is highlighted where it differs from that shown in example 1.

Input data

Input 1

% floor area type 1 = nil
% floor area type 2 = 85
% floor area type 3 = 15
% floor area type 4 = nil

Input 2

Floor area (TFA) (m^2) = 3500

Input 3

Annual electrical consumption (kWh) = 1 956 018
Annual gas/oil/coal consumption (kWh) = 572 505

Input 4

Local degree days = 2253

Input 5

Weekly occupancy hours = 168

Calculation

Degree day correction to heating (normally fossil fuel). The calculation for fossil fuel is shown as follows. If you have electric heating, discuss with your DEM.

$$\mathbf{572\ 505} \times \frac{2462}{2253} = \mathbf{625\ 614}\ \text{kWh}$$

Hours correction

Because the site operates over 24-hours, electricity and fossil fuels are adjusted separately (using the method described on page 12 of this Guide).

Fossil-fuel correction factor **(0.8)** × **625 614** = **500 491** kWh

APPENDIX 2

Because most office buildings comprise a combination of types, electricity consumption needs correcting on a pro rata basis to what would be expected from five-day week single-shift working:

$$\left(\frac{85}{100} \times 1\,956\,018 \times \frac{58)}{168}\right. + \frac{(15}{100} \times 1\,956\,018 \times \left.\frac{62}{168}\right) = \mathbf{682\,277.5}\ \text{kWh}$$

Site energy performance (fossil fuel)

$$\frac{500\,491}{3500} = \mathbf{L}_{\text{FOSSIL}}\ 143\ \text{kWh/m}^2$$

Site typical benchmark (fossil fuel)

Because most office buildings comprise a combination of types it is necessary to take this into consideration to arrive at a site typical benchmark, as shown below.

$$\frac{(85 \times 151)}{100} + \frac{(15 \times 178)}{100} = \mathbf{N}_{\text{FOSSIL}}\ 155\ \text{kWh/m}^2$$

Percentage improvement needed (fossil fuel)

$$\frac{(143 - 155)}{143} \times 100 = \mathbf{-8.4\%}\ (8.4\%\ \text{better than typical})$$

Site energy performance (electrical)

$$\frac{682\,277.5}{3500} = \mathbf{L}_{\text{ELECTRICAL}}\ 195\ \text{kWh/m}^2$$

Site typical benchmark (electrical)

$$\frac{(85 \times 85)}{100} + \frac{(15 \times 226)}{100} = \mathbf{N}_{\text{ELECTRICAL}}\ \mathbf{106}\ \text{kWh/m}^2$$

Percentage improvement needed (electrical)

$$\frac{(\mathbf{195} - 106)}{\mathbf{195}} \times 100 = \mathbf{46\%}$$

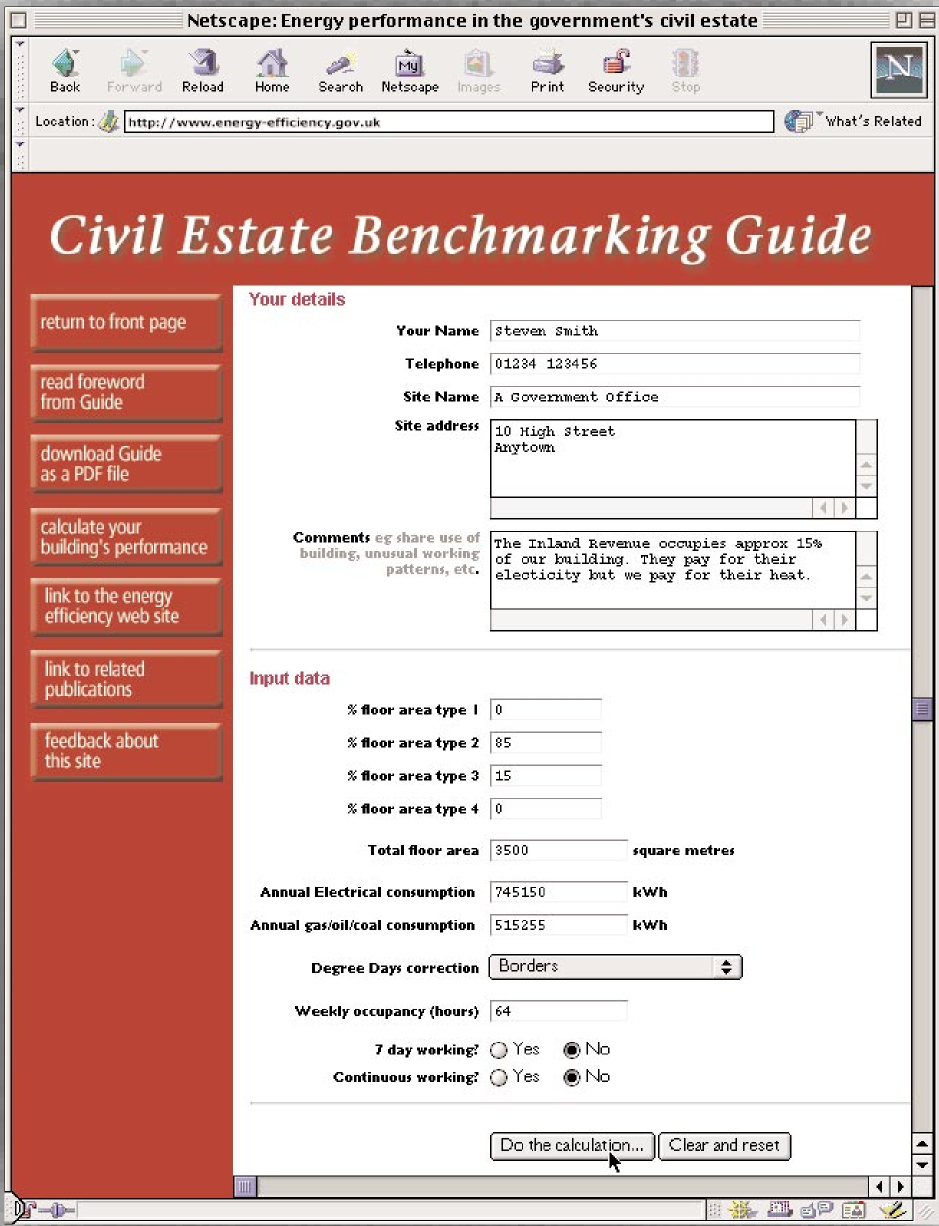
Summary table (please enter results to give overall site performance)

Fuel	Energy performance (kWh/m²)		Site typical (kWh/m²)		Improvement needed
Fossil	$\mathbf{L}_{\text{FOSSIL}}$	**143**	$\mathbf{N}_{\text{FOSSIL}}$	**155**	**–8%**
Electrical	$\mathbf{N}_{\text{ELECTRICAL}}$	**195**	$\mathbf{N}_{\text{ELECTRICAL}}$	**106**	**46%**
Overall	$\mathbf{L}_{\text{OVERALL}}$	**338**	$\mathbf{N}_{\text{OVERALL}}$	**261**	**23%**

In this example, fossil-fuel use is performing well so the advice is to maintain good operational practice. However, electrical energy use needs attention. Please refer to 'further analysis' on page 14 of this Guide for a breakdown on electrical energy end use.

APPENDIX 2

WEBSITE BENCHMARKING TOOL



APPENDIX 3 BENCHMARKS FOR OTHER BUILDING TYPES

Buildings other than offices are not covered in this Guide. The table below summarises benchmarks and sources of further information for other common building types in the civil estate.

Building type	Building-related energy consumptions kWh/m² per year		Source of further information
	Good practice	*Typical*	
Laboratories	–	1207	ECON 18
Storage/distribution	100	228	ECON 18
Prisons	550	650	EEB 12
Court buildings	220	280	EEB 12
Small retail	280	390	EEB 3

APPENDIX 4 DEGREE DAYS

During the heating season in the UK, the weather conditions vary from day to day and from month to month. This results in a variable heating load from year to year. The heat required to maintain an internal temperature, at say 19ºC, is dependent on the difference between the inside and outside temperatures.

One measure of this space-heating requirement is the use of degree days. This is defined as the daily difference in temperature between a base temperature and the 24-hour mean outside temperature when the base temperature is higher than the maximum daily temperature.

The **base temperature**, t_b, is defined as the outside temperate above which no space heating is required. The value normally adopted for the UK is 15.5ºC. It is assumed that internal heat gains (eg people, lighting, electrical equipment and solar gains) are sufficient to maintain a comfortable internal temperature at an outside temperature of 15.5ºC without the use of space heating. However, if the outside temperature falls below 15.5ºC then space heating is required.

The 24-hour mean outside temperature is taken to be the average between the maximum and minimum outside temperature. Hence the number of degree days in a day is:

$$t_b - ½ (t_{max} + t_{min})$$

Therefore for a t_{max} = 11ºC and t_{min} = 1ºC in one day:

number of degree days
= 15.5 – ½ (11 + 1) = 9.5 degree days.

The number of degree days in a month are usually added together and compared with the energy consumed for space heating. The relationship is usually linear and variations from this line can give warning of a particular problem which may otherwise go unnoticed, eg poor controls, boilers losing heat because they are not isolated, badly maintained burners or badly adjusted dampers.

The number of degree days over a year can vary considerably, eg in NE Scotland there are typically 2810 degree days compared to 1898 in Devon/Cornwall. It is for this reason that it is important to adjust energy consumption to a 20-year average degree day standard of 2462 degree days so that proper like-for-like comparisons are made. This standard is the basis of the benchmark performance figures in this Guide.

Cooling degree days can also be used to examine the performance of refrigeration plant providing summer cooling or other duties.

For a full explanation of degree days, obtain a copy of Fuel Efficiency Booklet (FEB) 7 'Degree days'.

Inserts

1 Boilers and boiler control
2 Heating controls
3 Domestic hot water (DHW)
4 Lighting
5 Air-conditioning
6 Water usage
7 Staff awareness campaign
8 Good housekeeping
9 Refurbishments
10 Checklist

Key

	No-cost measure – capable of being easily carried out by competent staff
	Servicing/repair of plant and equipment
£	Low-cost – funded at local level, often self-funded
££	High-cost – likely to require capital funding, eg departmental budget

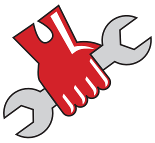
Typical saving opportunities

Boilers and boiler control

Insert 1

COMBUSTION

When monitoring combustion, the aim is to achieve the minimum excess air required for complete combustion of the fuel. This involves ensuring that the CO_2 content of the flue gas is the maximum possible and the oxygen (O_2) content is the minimum possible for a given firing rate, consistent with maintaining a smoke-free stack. The flue-gas temperature should be as low as possible without causing condensation of moisture and sulphur oxides.



Key saving

Regularly monitor boiler combustion efficiencies and set target efficiencies for the servicing contractors.

BOILER INSTALLATION

The heat loss due to radiation from a modern boiler may represent only 1.5% of the boiler's output at full load, but will increase to about 6% if the boiler is operating at only 25% load.

£

Key saving

Insulate poorly insulated boiler plant.

OFF-LINE FLUE LOSSES

The installation of a flue-gas damper or a fully closing damper on the burner will minimise the convection heat losses through a boiler when it is not firing.

£

Key saving

Prevent convection losses through boiler.

BOILER SEQUENCING

The highest boiler efficiencies typically occur between 70% and 90% of the rated firing capacity. Therefore, the boiler efficiency should be kept high by firing the boilers in this range for as much time as possible. Effective boiler sequence control enables only the minimum number of well-loaded boilers to operate to meet the system demand.

£

Key saving

Use boiler sequencer on multiple boiler installations.

This page forms part of Good Practice Guide 286 (GPG 286) 'Energy performance in the government's civil estate', produced by BRECSU as part of the Government's Energy Efficiency Best Practice programme. For further information on buildings-related topics contact: Enquiries Bureau, BRECSU, BRE, Garston, Watford WD2 7JR. Tel 01923 664258. Fax 01923 664787. E-mail brecsuenq@bre.co.uk

Typical saving opportunities

Heating controls

Insert 2

TIME CONTROL

Time switches

These bring the plant on and off according to set times of the day. These simple devices should only be used for installations below 100 kW. A resolution of better than 15 minutes should be used and a seven-day time switch should be used where occupancy hours differ between weekdays and weekends.

Optimisers

Optimiser controls are suitable for most intermittently heated buildings with an installed heating capacity greater than 100 kW.

Key saving

Ensure that time settings match the occupancy requirements and on larger installations use an optimiser.

COMPENSATORS

In a compensated system the flow temperature in the heating circuit is controlled relative to the external temperature. If a building is frequently overheated then the compensator slope may need adjusting.

Key saving

Check compensator settings.

NIGHT SET-BACK TEMPERATURE

The night set-back temperature is the heating set point for periods outside normal occupancy times. For most office buildings in the UK, a night set-back of approximately 10ºC is sufficient.

Key saving

Check night set-back temperature is appropriate.

LOCAL CONTROLS

Where local controls are fitted, eg thermostatic radiator valves (TRVs), zone valves, etc, it is important that their correct operation is checked, as a minimum, at the beginning of each heating season. Where TRVs are installed ensure that they are used correctly and not left on 'max'.

Key saving

Check operation of local controls.

HEATING SYSTEMS

All heating systems should be checked at least once per heating season (but preferably twice, once at the start and then again at the middle of the season) by utilising independent (ie not BMS-associated boiler controls that lend themselves to interrogation) portable instruments. These can be simple mechanical devices such as thermoscripts or electronic devices requiring a PC interface. Essentially they should provide a copy (hard or electronic) of the performance of the heating or air-conditioning systems showing the on/off times and space temperatures attined, over a period of, say, two weeks. Dependent on the recordings received, controls should then be re-set as shown to be necessary.

Key saving

Check operation of local controls.

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Typical saving opportunities
Domestic hot water (DHW)

Insert 3

CENTRAL OR DECENTRALISED DHW PRODUCTION

During the summer months, up to 90% of the energy used for providing hot water from central boiler/calorifier systems can be due to losses and inefficient generation. Considerable savings can be made by totally segregating generation of hot water from the heating system, or by decentralising hot water provision to point-of-use systems.

Key saving

Consider decentralising hot water provision.

DIRECT-FIRED WATER HEATERS

These units are inherently more efficient then boiler/calorifier systems as the water is heated directly. The potential for savings by the correct application of direct-fired water heaters is up to 50%.

Key saving

Consider direct-fired water heaters.

ELECTRIC WATER HEATING

Large storage cylinders that are fitted with electric immersion heaters, and built-in thermostats should be time-controlled as required. It is important to take advantage of any night-rate electricity tariff to minimise running costs.

Key saving

Ensure correct time and temperature control of immersion heaters.

Point-of-use electric water heaters can be very economical. It is, however, important to apply time control to units that have high standing losses, ie the casing is hot to touch.

Key saving

Fit seven-day time controls where standing losses are high.

STANDING LOSSES

Hot water storage and distribution systems should be adequately insulated to prevent high standing losses.

Key saving

Ensure all lagging is in good condition and thick enough.

TIME CONTROLS

In intermittently occupied buildings, hot water storage and distribution systems should be time-controlled. It is, however, important to avoid legionella formation and that the time settings match occupancy (for full guidance see CIBSE Technical Memorandum 13). This may necessitate the use of a time switch separate to that used for controlling the building's heating.

Key saving

Ensure good time and temperature control of DHW that matches demand patterns.

TEA POINTS

Due to the high standing losses from electric tea-point water boilers, time controls should always be fitted.

Key saving

Ensure all electric water boilers are time-controlled by seven-day time switches.

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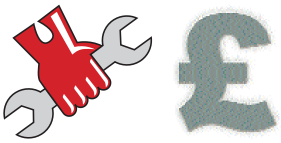
Typical saving opportunities
Lighting

LAMP EFFICACY*

Filament lamps (eg normal light 'bulbs') are the most inefficient type of light source, as evidenced by the waste heat they produce. As such, filament lamps generally have a low efficacy.

Discharge lamps (eg fluorescent tubes, sodium lamps, etc) are between four and fifteen times more efficient than filament lamps.

Where possible, use high-frequency fluorescent light fittings as these have a higher efficacy than standard fluorescent fittings.



Key saving

Use the highest-efficacy lamp possible, eg use compact fluorescent lamps in place of tungsten filament lamps.

MANUAL LIGHTING CONTROL

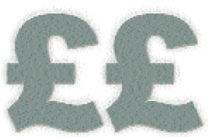
Switching arrangements should at least permit individual rows of luminaires parallel to windows to be controlled separately. Switches should be located as near as possible to the luminaires that they control. If groups of switches are used, simple labels should aid manual control.

Key saving

Encourage manual control of lighting wherever possible.

AUTOMATIC LIGHTING CONTROLS

Photoelectric control ensures that lighting will be turned off when the daylight provides the required illuminance. Where high-frequency fluorescent lighting is installed, consider using photoelectric controls to dim the light output when ambient light levels allow.



Proximity controls are designed to respond to the presence or absence of occupants.

Key savings

Install automatic lighting control wherever viable.

* Note: Lamp efficacy is the lumens output for the consumed electrical energy (watts). Filament (incandescent) lamps are of low efficacy because their lumens output is relatively low compared to the electricity consumed. Fluorescent lamps have a higher efficacy than filament lamps, producing more lumens output for a lower electrical consumption.

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Typical saving opportunities
Air-conditioning

Insert 5

Air-conditioning is the combination of refrigeration and humidity control (often within a warm air heating system), that provides air that meets certain quality parameters. In air-conditioned buildings, between 30% and 70% of the energy bill can be attributable to air-conditioning costs.

There are a number of key questions that need to the considered when operating air-conditioning:

- is air-conditioning actually necessary or would improved ventilation be adequate?
- can 'free cooling' by outside air be provided for some of the year instead of mechanical cooling?
- is it possible to separate all-year cooling requirements, such as communication equipment, from summertime-only comfort-cooling requirements?
- can cool air be recovered in the summer as well as hot air being recovered in the winter?

TIME CONTROL

Time control of air-conditioning plant is very important. This control must apply to all elements of the system, ie the refrigeration plant, fans, pumps, humidifiers, etc.

Key saving

Ensure good time control of all system elements to match occupancy patterns.

TEMPERATURE CONTROL

Over-cooling is extremely wasteful. It is recommended that the cooling set point in an office is not more than 3ºC below the ambient temperature. As such, with an ambient temperature of 27ºC, the cooling set point is 24ºC. If the ambient temperature increases to 29ºC, then the cooling set point is raised to 26ºC.

Key saving

Vary the cooling set point depending on ambient conditions.

COOLING AND HEATING

A very common cause for waste is when the building's heating system is operating at the same time as the air-conditioning. It is, therefore, important to ensure a dead band of at least 3ºC between the heating and cooling set point. This will prevent the heating and cooling systems 'fighting' each other.

Key saving

Ensure a minimum 3ºC dead band between heating and cooling set points.

COMMUNICATION ROOMS

Many communication rooms are continually air-conditioned to, say, 18ºC. Many modern items of communication and computing equipment have been designed to operate at ambient conditions of up to 35ºC. Some studies also indicates that cycling the temperature within communication rooms by 2ºC or 3ºC makes the equipment less susceptible to failure if there is a slight change in environmental conditions.

Key saving

Only air-condition if absolutely necessary.

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Typical saving opportunities
Water usage

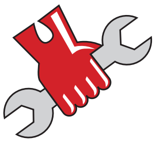
Insert 6

Water consumption should be analysed in the same way as that for electricity and fuel usage, ie against installed equipment and invoice information. Regular meter reading should be undertaken if invoice information is not available. This will highlight any unexplained changes in consumption and may indicate leakage.

Typical water consumption for an office building should be:

- no canteen – 25 litres/person/day
- canteen – 50 litres/person/day.

WATER-SAVING DEVICES



Tap restrictors are useful for providing equal flow at a number of taps in a wash room. Typically, they reduce water flow by up to 15%. Push taps are ideal for public areas where taps may be left running.

Key saving

Where possible, reduce water consumption at hand basins.

URINAL FLUSH CONTROLS

Urinal flush controls limit the flushing from the traditional continually flushing cisterns. These controllers prevent water usage when urinals are unused for long periods but they include a periodic ‘hygiene’ flush.

Key saving

Fit urinal flush controls.

WATERLESS URINALS

Waterless urinals are becoming more popular as the technology improves. They should, however, only be used where there is a reliable cleaning regime.

Key saving

Consider installing waterless urinals.

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Typical saving opportunities
Staff awareness campaign

There is a much greater chance of minimising energy costs if building occupants are thinking about it on a regular basis. Awareness campaigns should set out the roles and formal responsibilities of the individuals selected to achieve management targets. These tasks should be built into individual job descriptions (see 'Roles and responsibilities', section 2).

WHY DON'T PEOPLE SAVE ENERGY?

There are five fundamental reasons why people do not save energy:

- they are not aware of the need to save energy
- they do not recognise their role
- they do not know where to save
- they do not know how to save
- they are not motivated to save.

The way to overcome some of these barriers is to change people's attitudes and give them a sense of responsibility for energy usage. By increasing their awareness and providing technical assistance this can be achieved.

AWARENESS TECHNIQUES

There are a number of key methods that can be used to improve the awareness of staff. These are:

- talking to people (individually)
- awareness talks (groups)
- publicity, ie posters, energy/environmental display boards, newsletters, etc
- competitions
- training
- energy wardens
- regularly circulating energy performance figures.

IMPROVING MOTIVATION

The most successful way of improving motivation is to offer some kind of incentive or reward as a bonus in peoples' pay packets. Any savings may be maximised by introducing some form of interdepartmental competition. This form of competition helps to create a positive goal and promotes a team spirit amongst the participants, and can also attract positive publicity. The more people that are aware, the greater the chance of reducing energy costs.

For further information please refer to GPG 84 'Managing and motivating staff to save energy'.

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Typical saving opportunities
Good housekeeping

Insert 8

OFFICE EQUIPMENT

Office equipment can typically account for up to 20% of the energy used in offices. Good management of office equipment can create worthwhile energy savings. For further information, please refer to GPG 118 'Managing energy use. Minimising running costs of office equipment and related air-conditioning' and GPG 276 'Managing for a better environment. Minimising running costs and impact of office equipment'.

MANUAL SWITCHING OFF

Staff should be encouraged to switch off equipment whenever it is not being used, providing it is cost-effective to do so. This is particularly applicable to computer screens as these can be switched off while the computer itself remains on. There are, however, times when it can take too long to bring some equipment back into operation (eg large photocopiers, etc) for it to be cost-effective to switch them off for relatively short periods.

Key saving

Where possible, all equipment should be switched off during lunch hours, at night and at weekends, unless specifically required, eg network servers, equipment connected to outside line modems, etc.

ENERGY-SAVING FEATURES

Energy-saving features built into office equipment (eg Energy Star compliant equipment) should be enabled. These features typically include:

- automatic standby mode
- automatic switch off.

Key saving

All equipment should have energy-saving features enabled. If Energy Star equipment is purchased, it is essential that the software is set up correctly on each machine, otherwise the initial extra capital cost would have been in vain!

POPULAR MISCONCEPTIONS

"Switching off fluorescent lights costs more than leaving them switched on"

NO!

If a fluorescent light is not required, it is always more efficient to turn it off rather than to leave it on.

"Computer screens in 'screen saver' mode save energy"

NO!

When a computer screen is in 'screen saver' mode it does not save any energy. Screens should be turned off rather than leaving them in screen saver mode.

"Turning off personal computers can damage the equipment and lose valuable data"

NO!

A personal computer should always be turned off when left unattended for more than, say, 30 minutes. Turning it on and off does not cause damage.

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Typical saving opportunities

Refurbishments

Insert 9

Energy efficiency measures can often be incorporated during refurbishment works at marginal extra cost. Such opportunities should not be missed.

ROOFS

Insulating pitched roofs at ceiling level gives a good rate of return at any time.

Flat roofs should be insulated during refurbishment work.

Older (type 1) office buildings often have high ceilings. Installing a new false ceiling with insulation at ceiling level can reduced the heated volume.

WALLS

Where external surfaces of walls require attention for structural or other reasons, insulating the wall at the same time should be considered.

Addition of insulation to the internal face of external walls should be carried out during refurbishment to minimise the potential disruption to occupants.

If internal refurbishment is to be carried out, adding insulation between timber studs or using a composite board should be considered.

FLOORS

Where there is access to the underside of suspended timber floors, adding insulation between the joists is cost-effective.

Where existing solid floors need to be renewed, this is an opportunity to add insulation.

WINDOWS

Where window frames are in poor condition and need replacing, consider installing 4-12-4 double-glazing, with a low-emissivity (low-e) coating.

Many post-war office buildings were designed with a large area of single glazing. During refurbishment, consideration should be given to replacing some of the low-level glazing with insulated panels.

Where control of solar gain is required, the installation of external shading devices should be considered.

DOORS

Providing a draft lobby at frequently used entrances to a building can make a significant contribution to reducing ventilation heat loss.

LIGHTING

When fluorescent lighting is being replaced, consideration should be given to using high-frequency fittings.

When new lighting is being installed, ensure that all control options are considered and that sufficient manual switches are provided.

HEATING

Where a building under refurbishment is a long way from a central boiler house, decentralisation may be appropriate.

Good controls are an important part of energy management. It is recommended that, as far as possible, controls are made tamper-proof and should include time switches, optimisers, compensators, TRVs, zoning, etc.

Any redundant pipework should be isolated or removed.

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Typical saving opportunities

Checklist

Insert 10

REGULAR ACTIVITIES

- Read all utility meters, ideally monthly.
- Monitor consumption and compare with previous performance.
- Report/publish performance.

CHECKS FOR ENERGY WASTE WHEN A BUILDING IS OCCUPIED

- Are areas suffering from overheating or excessive cooling?
- Are the lights off in unoccupied areas?
- Are lights off where daylight is sufficient?
- Are light fittings clean?
- Are windows and doors open when the heating/air-conditioning is on?
- Is office equipment left on at unoccupied workstations?
- Are portable electric heaters in use?
- Are there obstructions in front of radiators or heaters?
- Are blinds being used to minimise solar gain in air-conditioned areas?
- Are taps dripping?
- Is external or security lighting on during daylight hours?

CHECKS FOR ENERGY WASTE OUTSIDE NORMAL OCCUPANCY

- Are all lights switched off?
- Do cleaners switch off all lights?
- Are doors and windows closed?
- Are all fans switched off?
- Are there any items of office equipment left on?
- Are vending machines switched off?

For further information please refer to GPG 117 'Energy efficiency in the government estate – for accommodation managers'.

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REFERENCES AND FURTHER INFORMATION

REFERENCES

[1] ***Energy Efficiency Best Practice programme.*** Energy Consumption Guide 19 'Energy use in offices'. DETR, London, Revised January 2000 (BRECSU)

[2] ***Energy Efficiency Best Practice programme.*** Good Practice Guide 167 'Organisational aspects of energy management: a self-assessment manual for managers'. DETR, London, 1994 (BRECSU)

[3] ***Energy Efficiency Best Practice programme.*** Good Practice Guide 200 'A strategic approach to energy and environmental management'. DETR, London, 1996 (BRECSU)

[4] ***Energy Efficiency Best Practice programme.*** Good Practice Guide 117 'Energy efficiency in the government estate – for accommodation managers'. DETR, London, 1993 (BRECSU)

[5] ***Energy Efficiency Best Practice programme.*** Good Practice Guide 84 'Managing and motivating staff to save energy'. DETR, London, 1993 (ETSU)

[6] ***Energy Efficiency Best Practice programme.*** Good Practice Guide 71 'Selecting air conditioning systems – a guide for building clients and their advisers'. DETR, London, 1993 (BRECSU)

[7] ***Energy Efficiency Best Practice programme.*** Good Practice Guide 31 'Computer aided M&T for industry'. DETR, London, 1991 (ETSU)

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Best Practice programme publications are available from the BRECSU and ETSU Enquiries Bureaux. Contact details are given below.

Energy Consumption Guide

18 Energy efficiency in industrial buildings and sites

Fuel Efficiency Booklet

7 Degree days

Good Practice Guides

33 Energy efficiency in offices. Understanding energy use in your office

91 Monitoring and targeting in large manufacturing companies (ETSU)

118 Managing energy use. Minimising running costs of office equipment and related air-conditioning

186 Developing an effective energy policy

276 Managing for a better environment. Minimising running costs and impact of office equipment

Introduction to Energy Efficiency

3 Shops and stores

6 Offices

12 Prisons, emergency buildings and courts

FURTHER INFORMATION

Regional environmental and energy management contacts

Regional environmental and energy management contacts provide a local point of contact, source of information and support.

Scotland	0141 248 4774
North East	0191 202 3614
Yorkshire & The Humber	0113 283 6376
North West	0151 224 6468
East Midlands	0115 971 2476
West Midlands	0121 212 5300
Wales	01222 825172
Eastern	01234 796194
South West	0117 900 1800
South East	01483 882318
Northern Ireland	028 9262 3000
London	020 7217 3054

The Government's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

For further information on:

Buildings-related projects contact:
Enquiries Bureau
BRECSU
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Fax 01923 664787
E-mail brecsuenq@bre.co.uk

Industrial projects contact:
Energy Efficiency Enquiries Bureau
ETSU
Harwell, Oxfordshire
OX11 0RA
Tel 01235 436747
Fax 01235 433066
E-mail etsuenq@aeat.co.uk

Internet **BRECSU** – http://www.bre.co.uk/brecsu/
Internet **ETSU** – http://www.etsu.com/eebpp/home.htm

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy-efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.